Geophysical Research Abstracts
Vol. 19, EGU2017-7013, 2017
EGU General Assembly 2017

Parameter resolution and cross-talk for Elastic Full Wavefrom Inversion

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Elastic Full Waveform Inversion (EFWI) is a computationally intensive method for iteratively estimating elastic subsurface model parameters. A cornerstone of EFWI is the numerical solution of the elastic wave equation, which is used as a tool to quantify the discrepancy between the synthetic (modelled) and true (real) measured seismic data at the receiver locations. The difference between the modelled and real recorded data is subsequently used to update the synthetic model to yield a better match between the modelled and true receiver data. A common approach to the EFWI problem is to use a non-linear conjugate gradient search method for the updates. The resolution and cross-coupling for the estimated parameters can then be found by computing the Hessian matrix.

For application to exploration seismic data, resolution of the estimated model parameters depend on the chosen parametrisation, acquisition geometry and temporal frequency range. Although some experience has been gained, it is still not clear which elastic parameters can be reliably estimated. Previous analyses, with some exception, have been based on simplistic arguments using radiation pattern analysis.

We use a known adjoint-state technique to compute the Hessian for realistic exploration cases and analyse parameter resolution and cross-coupling for different selections of models, acquisition geometries and data types, including streamer and Ocean Bottom Seismic recordings. The information on resolution obtained from the exact Hessian is essential for evaluating the quality of estimated parameters due to the strong influence of source-receiver geometry and frequency content. For typical exploration type models and acquisition parameters unbiased estimates of pressure- and shear wave velocities can be obtained, but density appears to be coupled strongly to other parameters.